



Evaluation of Neuroimaging Correlates of Focal vs. Generalized Seizures

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DESCRIPTION

Epilepsy is a neurological disorder characterized by recurrent seizures, which can manifest as focal (partial) or generalized seizures. Understanding the underlying neuroimaging correlates of these seizure types is essential for accurate diagnosis, treatment planning, and prognostic assessment. This review explains the neuroimaging findings associated with focal and generalized seizures, exploring their differences, implications, and current research trends. Neuroimaging plays a pivotal role in the evaluation of epilepsy, aiding clinicians in identifying structural abnormalities, functional alterations, and network dysfunctions associated with seizure activity.

Neuroimaging modalities used in epilepsy assessment

Magnetic Resonance Imaging (MRI): MRI is widely employed to visualize structural abnormalities such as hippocampal sclerosis, cortical dysplasia, tumors, and vascular malformations, which can be implicated in focal seizures.

Computed Tomography (CT): Computed tomography scans are useful in the acute settings to identify hemorrhages, tumors, or structural lesions that may trigger seizures symptoms.

Functional MRI (fMRI): fMRI assesses brain activity by detecting changes in blood flow, helping to map functional areas and understand how epilepsy affects brain networks.

Positron Emission Tomography (PET): PET scans measure brain metabolism and can highlight areas of abnormal glucose utilization or identify epileptogenic zones.

Single-Photon Emission Computed Tomography (SPECT): SPECT imaging captures cerebral blood flow patterns during seizures, aiding in localization of seizure foci.

Focal seizures- neuroimaging correlates

Focal seizures originate from a specific area of the brain and are characterized by localized symptoms. Neuroimaging studies often reveal structural lesions or abnormalities in the vicinity of the seizure focus. Common findings include:

Mesial Temporal Sclerosis (MTS): This is a frequent cause of focal seizures, particularly in temporal lobe epilepsy. MRI may show hippocampal atrophy, abnormal signal intensity, or loss of internal structure.

Cortical dysplasia: Structural MRI can detect abnormalities in cortical development, such as cortical thickening, blurring of gray-white matter junctions, or abnormal gyration patterns.

Neoplasms: Tumors or brain lesions can act as epileptogenic foci. MRI with contrast enhancement is important for identifying these lesions.

Vascular abnormalities: Arteriovenous malformations, cavernous malformations, or stroke-related changes visible on MRI may predispose individuals to focal seizures.

Generalized seizures- neuroimaging correlates

Generalized seizures involve bilateral brain involvement from the onset, affecting widespread neuronal networks. Neuroimaging findings in generalized seizures often show more diffuse or symmetric abnormalities, including:

Normal structural imaging: Generalized seizures may not always show focal lesions or structural abnormalities on routine MRI, posing challenges in localization.

Functional connectivity alterations: Advanced neuroimaging techniques such as fMRI reveal disruptions in functional connectivity networks involving thalamocortical circuits and default mode network.

Metabolic abnormalities: PET scans may demonstrate generalized hypometabolism or hyper metabolism patterns in specific brain regions associated with seizure propagation.

Genetic syndromes: Certain genetic epilepsies, such as Dravet syndrome or Lennox-Gastaut syndrome, may present with characteristic MRI findings such as cortical atrophy or dysgenesis. The neuroimaging correlates of focal vs generalized seizures have significant clinical implications.

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Precise localization of seizure foci through neuroimaging helps in surgical planning for patients with drug-resistant focal seizures, aiming to resect the epileptogenic zone while preserving essential brain functions. Neuroimaging findings can influence prognosis by predicting the likelihood of seizure control with medication or surgical intervention. Ongoing research focuses on refining neuroimaging techniques to enhance spatial resolution, sensitivity, and specificity in detecting subtle structural or functional abnormalities associated with different seizure types. Advancements in neuroimaging technologies hold potential for further elucidating the complex mechanisms underlying epilepsy:

Complex mechanisms underlying epilepsy

High-field MRI: Increasing MRI field strengths improve spatial resolution, enabling better visualization of small lesions or subtle cortical abnormalities.

Machine learning and AI: Integration of machine learning algorithms with neuroimaging data can aid in automated

detection of epileptogenic lesions and prediction of treatment outcomes.

Connectomics: Studying brain connectivity patterns using Diffusion Tensor Imaging (DTI) and resting-state fMRI may reveal aberrant networks contributing to seizure genesis and propagation.

In conclusion, neuroimaging plays a pivotal role in the evaluation and management of epilepsy, providing valuable insights into the neuroanatomical and functional correlates of focal and generalized seizures. While focal seizures often exhibit localized structural lesions detectable by MRI, generalized seizures may involve more diffuse network disturbances evident through advanced imaging techniques. Continued advancements in neuroimaging technology and methodologies offer exciting prospects for improving diagnostic accuracy, treatment efficacy, and our understanding of epilepsy as a whole. Integrating these findings into clinical practice will be essential for optimizing personalized treatment strategies and improving outcomes for individuals living with epilepsy.